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# STORY OF ZERO

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# STORY OF ZERO

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Children's Book Trust, New Delhi

# ZERO
## Oh! No!

One would exclaim on being marked thus in an examination. It has indeed nothing to offer. In spite of it, think of the modern world without the presence of zero.

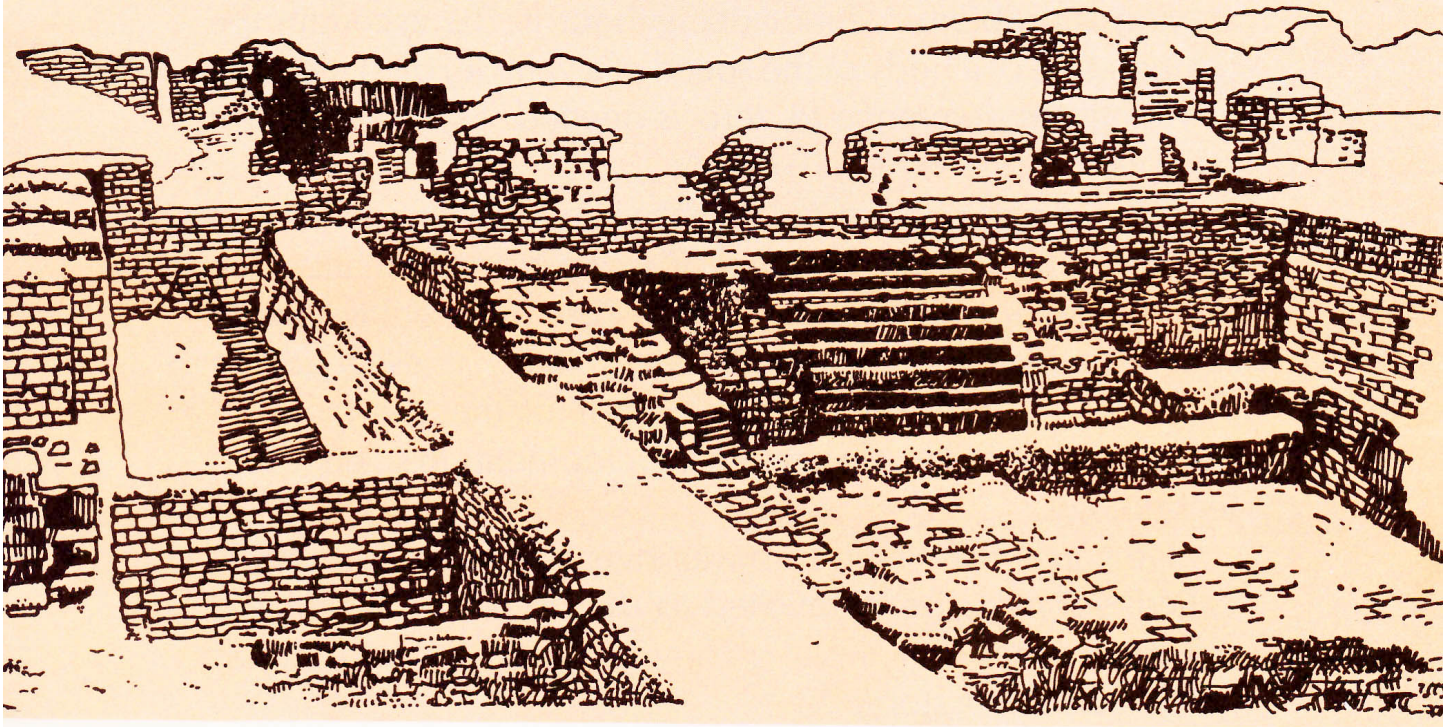
A simple equation like $ax^2 + bx + c = o$, employed for solving a problem, cannot do without it. To ascertain the temperature of a body or the speed of a vehicle, or to measure anything, the reference to zero *is* needed. Even a superfast computer uses zero in its working.

Zero is one of the most brilliant intellectual inventions of all times to come. The concept gave mathematics the completeness which it was lacking. Zero drew out its usefulness, subtlety, beauty, and glory. Initially it escaped the notice of the greatest mathematicians of the West, but in position it has led to the present developments in science and technology.

Do you know where zero was invented? India. It was then called 'soonya'. As it travelled to distant lands, it acquired different names until it was widely accepted as 'zero'. It has had a fascinating story.

Indians were adept at mathematics from the days when the cities of Mohenjo-daro and Harappa prospered, as far back as 3,000 B.C. The uniform size of their bricks, accurate weights and measures and systematic town planning throw much light on the mathematical mind of the inhabitants. In ancient India, mathematics, known as 'Ganita', the science of calculation, was held in high esteem. It is considered the highest of all sciences in sacred texts, the *Vedas*, the supreme religious books of the Hindus. The Hindu (Indian) numbers,

*Some ruins of the Indus Valley Civilisation*

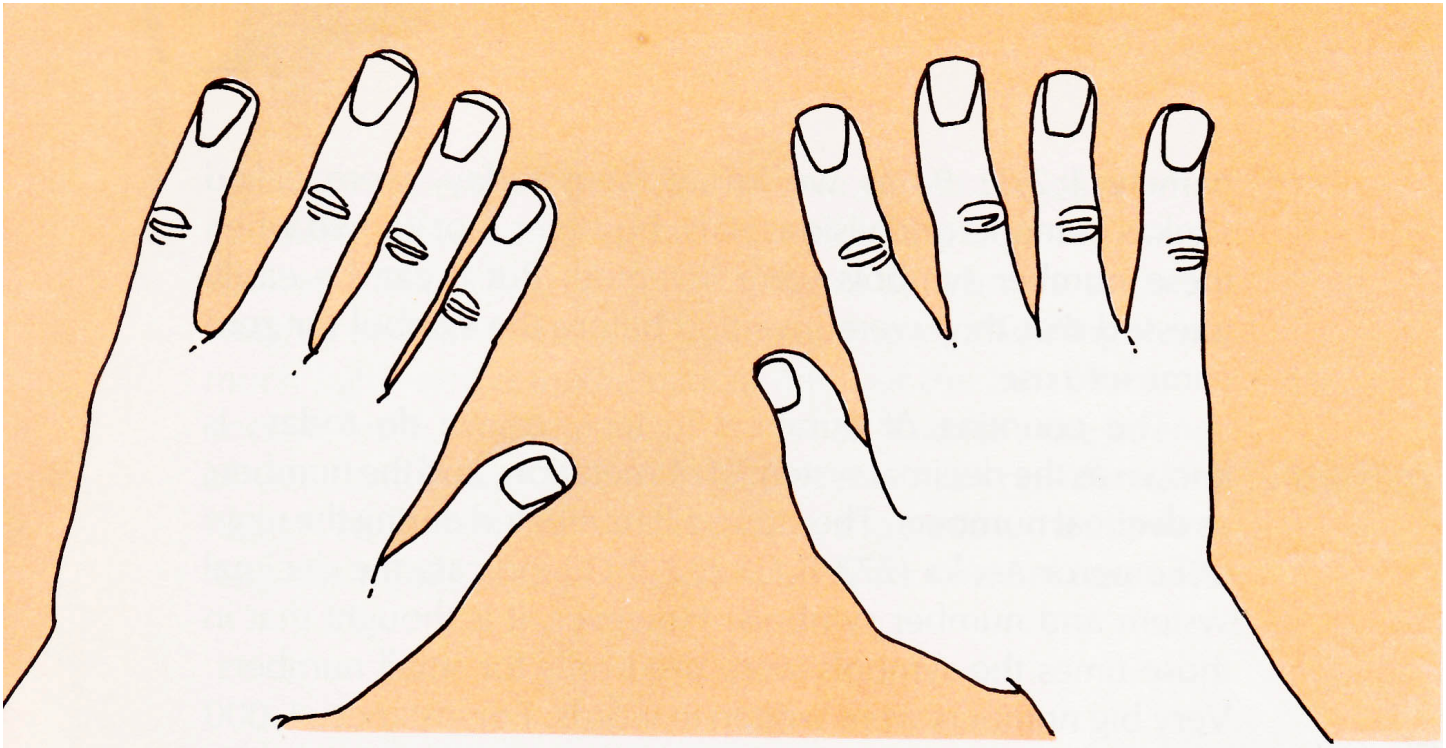


namely 1,2,3...9, as we know them today, were called 'Ankas' — marks or divisions. It is, however, not known when these number symbols were invented. But it can be easily guessed that they were invented before the symbol for zero came into use.

The counting of numbers in tens, as we do today, is known as the decimal system of numeration, and the numbers as decimal numbers. The stone pillars erected during the reign of Emperor Asoka (273 B.C.-232 B.C.) indicate the decimal system and number symbols. However, it is thought that in those times the symbols were used only for small numbers. Very big numbers were written in words. For instance, 1,000 was called 'sahasra', 10,000 'ayuta', 100,000 'laksha', 10,000,000 'koti', and so on. Numbers were named after things seen or used in daily life. For instance, moon or earth represented one, eyes or hands or twins represented two, and so on.

It is said that thinking up big numbers and naming them was the favourite pastime of ancient Indian mathematicians. While making up big numbers, they would employ the fingers of their hands. As there are five fingers to each hand, making a total of ten, their counting system had ten numbers and multiples of ten. This system of measuring numbers in terms of ten, whether multiplying or dividing, is known as the decimal numeration system. For instance,

$\frac{1}{2}$ is taken as $\frac{1 \times 10}{2 \times 10} = \frac{5}{10} = 0.5$, where the dot is the decimal point. Similarly, 15.67 is $15\frac{67}{100}$, $120 = 12 \times 10$, and so on. This is how the decimal system of numeration began in India.



Likewise, the 'position value notation' came into being when the ancient mathematicians wrote down a mass of numbers in words. In due course, this system was adopted in writing the number symbols. To explain position value notation, take the number 7,456. It can be broken down into multiples of ten thus:

$$\begin{aligned} 7{,}456 &= 7\text{x}10\text{x}10\text{x}10 + 4\text{x}10\text{x}10 + 5\text{x}10 + 6 \\ &= 7\text{x}1{,}000 + 4\text{x}100 + 5\text{x}10 + 6 \\ &= 7{,}000 + 400 + 50 + 6 \end{aligned}$$

In other words, it is 7's position in the number that makes it seven thousand. Likewise, 4's position makes it four hundred, and so on. It is, therefore, the position of a digit in a number that determines its value.

The earliest reference to position value notation is found in *Agni Purana,* an ancient Indian text written about a century

after the birth of Jesus Christ. Ancient Indian mathematicians had, therefore, the skill to write numbers as big as $10^{18}$ (ten multiplied by 10, eighteen times), while ancient Greek and Roman mathematicians could count only up to $10^4$ or 10x10x10x10 and $10^3$ or 10x10x10 respectively. The cumbersome number system of the Romans consisting of M's, C's, X's, I's, and so on, did not allow them to count beyond a particular number and to invent the position value notation.

However, in ancient India only the learned had the privilege of counting numbers and performing calculations. The ordinary people remained ignorant. Nevertheless, mathematics continued to be a respected subject, a tradition that continued even when Buddhism and Jainism spread in the land. Through Buddhism, Indian numbers spread to China and Japan. Some Hindu merchants settled down in the countries of the Far East and introduced Indian numbers there.

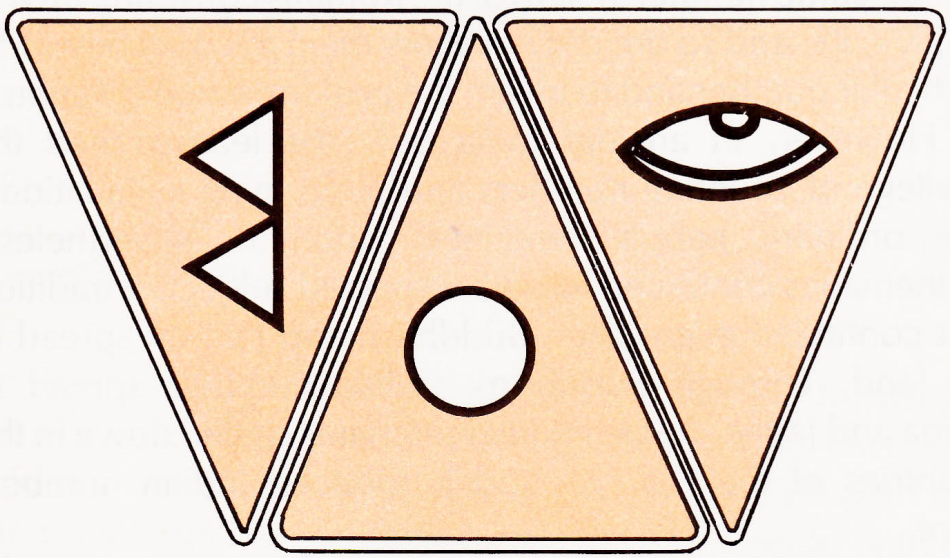
It was, however, not until zero was invented that mathematics prospered in India. The decimal numbers and position value notation did not click till zero was added. The position value notation makes no sense without zero because it is zero that makes 26, for instance, different from 206 or 20,006. It is the position of zero in the number that adds a new meaning to it. Calculations also became simpler and faster.

Nothing is known about who invented zero, where or when. It is claimed that Indians knew about it even before the Christian era. The ancient seer Pingala and the political philosopher and statesman Kautilya have mentioned it several times in their works.

In those ancient times, zero was represented as a circle with a dot at its centre. In Sanskrit, the language then popular

in India, it was called 'soonya' – void or emptiness. In those days, when Sanskrit was spoken all over the country, zero had several names like 'kha', 'gagana', 'akasa', 'nabha', 'ananta', which denote sky, void or endless or completeness.

*Ancient representations of zero*



The Mayas of Central America had also invented zero but they did not know the principle of numbers, as Indians did, to enable them to develop mathematics. It is claimed that the Babylonians also knew about zero but, again, they did not use it as a symbol. The availability of abacus there was responsible for this. An abacus – often seen as a toy today – is a counting frame with coloured beads strung in rows. The beads are moved to count. However, as and when zero appears, it is left as an empty space between the beads. So, the Babylonians knew zero and used it but never wrote it down once calculations on the abacus were over!

In the absence of the abacus in India, merchants had to denote zero symbolically. Indian mathematicians immediately

sensed its importance and adopted it in calculations. In fact, Indian numbers are as good as numbers invented in Greece or Babylon or Central America. It is but the presence of zero and position value notation which imparted to them a richness not known till then in mathematics.

Initially, zero was invented to signify 'nothing' in the place of a number. If somebody had seven mangoes and all seven were eaten, 'nothing' was left. The Mayas of Central America had invented zero in this sense only. It took the ingenuity of Indian mathematicians to understand the significance of zero and accept it as an additional number. Their subtle mind gave the status of a number to 'nothing'. The eminent Multan-born Indian mathematician Brahmagupta (598 A.D. – 660 A.D.) went on to give the rules of operation of zero in his treatise *Brahmasphutasiddhanta* as though zero were any other number. Today, his rules may sound trivial, but imagine their significance when zero was 'nothing' in the rest of the world. Brahmagupta claimed:

$A + 0 = A$, where A is any quantity
$A - 0 = A$
$A \times 0 = 0$
$A \div 0 = 0$

In the case of division of a quantity by zero Brahmagupta faltered. The division of a quantity by zero is infinity and not zero.

This mistake was corrected some centuries later by another great Indian mathematician Bhaskara (1114 A.D. – 1185 A.D.), a native of Bijapur, Karnataka. In his famous

book *Leelavati*, Bhaskara claimed that the division of a quantity by zero is an infinite quantity or immutable God, which does not change when worlds are created or destroyed.

Meanwhile, the creation of zero led Indian mathematicians to think of numbers less than zero itself. So came into circulation the negative numbers, namely, –1, –2, –3 ...an important development that led to several advances in algebra. Various types of higher order algebraic equations could thus be solved. Astronomy also benefited from these developments.

From sixth century to tenth century, for about 400 years, India became the centre of mathematics in the world. Naturally, at that time, the fame of mathematics in India had spread far and wide. Even as early as in 662 A.D. a Syrian bishop Severus Sebokht, residing on the bank of the river Euphrates, was impressed by the Indian method of calculations. He wrote that Indian computing 'surpasses description'.

The torch of mathematics had been lit. Its applications in astronomy and other subjects had also been made.

Even earlier than the eleventh century, important works of Indian mathematicians had already been passed on to the Arab world, which had meanwhile established itself.

With the rise of the Arab civilization, trade exchanges among Arabs, Greeks and Indians had begun. Sometimes, scholars also accompanied the caravans of traders and merchants to visit new lands and gain knowledge. Under the Khalifa Al-Mansur, the Arab ruler of Baghdad, a number of emissaries and scholars were sent to Sind (now in Pakistan) in the eighth century to learn astronomy, mathematics and medical science in India. Not only were a number of great Indian texts on various sciences, including mathematics,

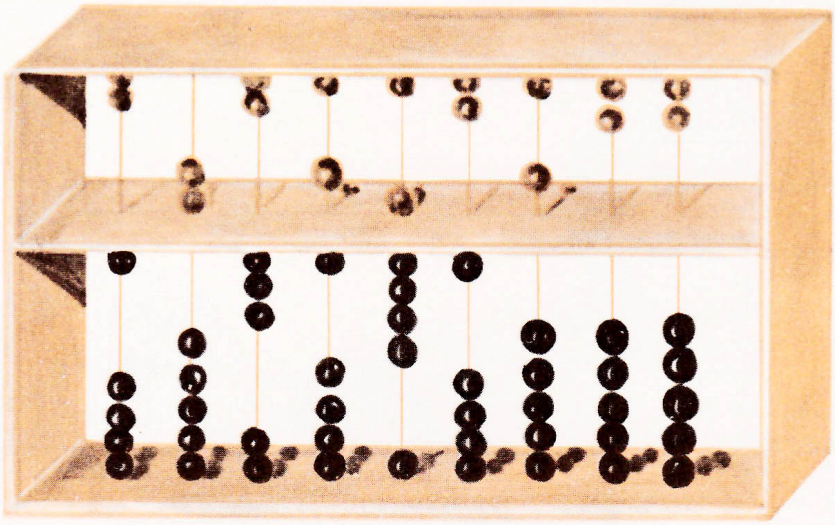
brought to Baghdad for study but also translated into Arabic.

Arabic centres of learning grew up at Cordova, Granada and Toledo. Academies and libraries were established. Astronomical observatories were built. Considerable scientific thought and learning began at these centres. The Arabic scholars came into contact with the local Europeans. The latter had always considered Greece to be the home of sciences and looked down upon Arabic learning. Arabs, therefore, brought scientific texts from India to show them that there were places other than Greece where science had developed and prospered. In this manner, zero, Indian decimal numbers and position value notation entered the Arab world and spread.

Arab mathematicians read Indian works and also began to use Indian numbers, including zero. But their popularisation in the Arab world was left to the great Arab mathematician Al-Khowarizmi (790 A.D. – 850 A.D.) of Al-Mamun's scientific academy at Baghdad. In about 830 A.D. he visited India and saw Indian mathematicians performing calculations with ease and speed. Back in Baghdad, he wrote his famous treatise *Hisab-al-Jabr wa-al-Muqabala* (Calculation for Integration and Equation) which caught the attention of the Arab world and made Indian numbers popular. 'Soonya' became 'al-sifr' or 'sifr'. One can judge the impact of his treatise from the fact that the title of his treatise 'al-Jabr' became the 'Algebra' of today.

In due course, Arabs realised that Indian numbers, including zero, and position value notation provided something which Greek mathematics lacked. So they became highly secretive about them. No European or non-Muslim was allowed to enter the Arabic centres of learning. This aroused the curiosity of the Europeans. Eventually, in the twelfth

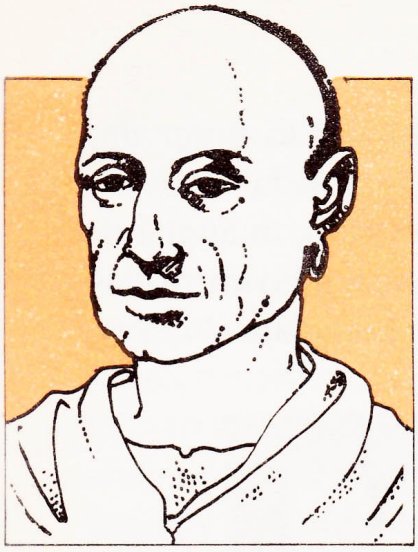
century, a monk, Adelard of Bath, managed to enter the Cordova centre disguised as a believer of Islamic faith. Later, he translated Al-Khowarizmi's treatise into Latin, in England. His Latin version popularised Indian numbers, then known as 'Arabic numbers', among European mathematicians.



*An abacus*

Meanwhile, a Frenchman named Gerbert (940 A.D. – 1003 A.D.), a politician and mathematician of some repute (Pope Sylvester II), during his travels, came to know of the 'Arabic numbers'. Fascinated, he made efforts to teach Europeans about them.

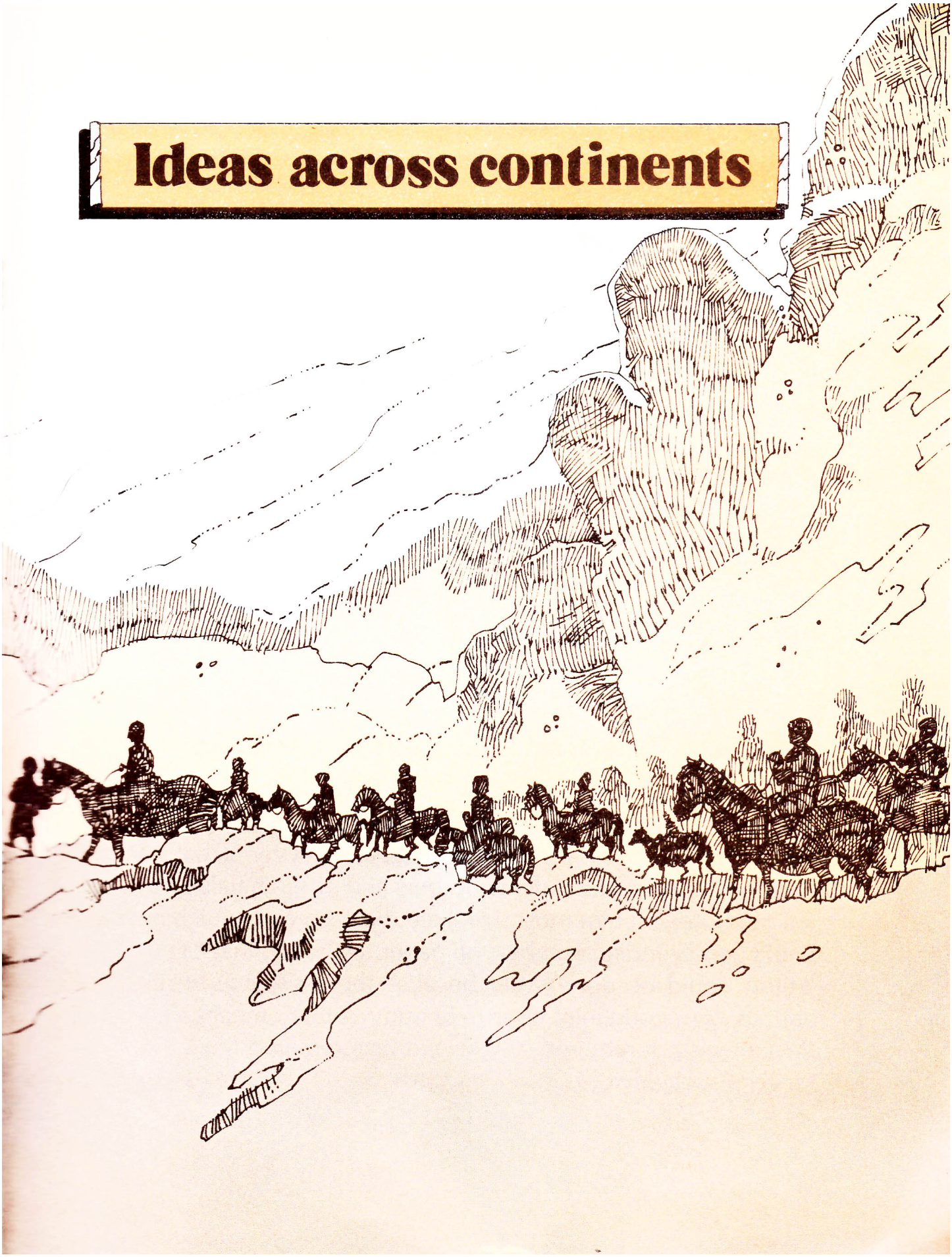
The mathematician who played the pivotal role in popularising Indian numbers in Europe was Leonardo da Pisa, often known as Leonardo Fibonacci ( 1170 A.D. – 1230 A.D.). He was the son of a warehouse official at Bougie, Algeria, then a centre of trade in Africa. An Arab taught him the Indian numbers during his childhood. As a youngman he travelled extensively to countries like Egypt, Syria, Greece,



**Bhaskara**
**(1114-1185)**

An ancient Indian mathematician and astronomer. He was the first to declare that any number divided by zero is infinity and that the sum of any number and infinity is also infinity. He is famous for his book *Siddhanta-siromani*. He propounded a concept which enabled astronomers to determine the movement of the planets accurately.

# Ideas across continents



**Al-Khowarizmi**
**(790-850)**

A great Arab mathematician and astronomer. His work on elementary mathematics *Hisab – al – Jabr wa – al – Muqabala* was of great significance. He compiled a set of astronomical tables, based largely on the Arabic version of *Brahmasiddhanta.*

**Leonardo Fibonacci**
**(1170-1230)**

An Italian. He was an outstanding mathematician of medieval Europe. His most famous work is called *Liber Abaci* and it was instrumental in introducing Arabic numerals into Europe.

and Italy, and met a number of local merchants and mathematics scholars. Of all the various mathematical systems that he came to know of, the Indian numbers and position value notation impressed him most. He liked the ease with which he could handle Indian numbers on paper. He found that calculations could be done faster because the assistance of the abacus or counting board or any other mechanical device was not required. Other numbers required the assistance of such devices.

In 1202, Fibonacci wrote the book *Liber Abaci* (Book of Computation) in Latin on Indian numbers and strongly urged European mathematicians to use them. In those times, Europe had no tradition in mathematics. Monasteries were the only places with some knowledge of the subject. It was simply used to calculate the date of Easter. Fibonacci's book, therefore, remained a standard text on mathematics for the next two centuries.

It led to the growth of interest in mathematics in Europe, which eventually led to advancements in science and technology. The Arabic 'sifr' (zero) became Latinised to 'zephirum'. It went on to acquire different names as it travelled to different European countries, each calling it by a local name. Thus 'zephirum' became 'zenero', 'zepiro', 'iziphra', 'zephrio', 'cenero', 'cypher', and so on.

In the beginning, merchants familiar with Roman numbers found Indian numbers difficult to understand. They could not appreciate the role of zero or position value notation. University scholars also found the numbers too novel to swallow. Everybody felt that using the numbers was like learning a new language. Europeans often referred to these numbers as 'infidel numbers' because they were then believed to be of Arabic origin. Arabs were then treated as infidels in Europe because they had invaded the holy land of Palestine.

Some Europeans felt the numbers to be a code language. Using them was called 'ciphering'. That is how even today the English word for breaking a code is known as 'deciphering' and the key to the code language as a 'cipher'!

Nevertheless, apart from simplifying calculations, Indian numbers also assisted in astronomical calculations and thereby in accurate navigation. Travel across seas thus

increased as did the trade exchange between different countries. In 1299, the numbers became so popular in the prosperous city of Florence, Italy, the centre of Arab-Europe trade, that their use by bankers and merchants was banned through a special law!

Meanwhile, in the twelfth and thirteenth centuries came the Crusades. Europeans launched these military expeditions to recover the Holy Land of Christ occupied by Arabs. On their way to Palestine, European soldiers crossed the region of the Mediterranean sea and while returning they often carried with them the knowledge of Indian numbers.

The Turks had conquered the Byzantine Empire and captured the famous city of Constantinople in 1453. Scholars of the city fled to distant lands in Europe, taking along with them the Indian numbers, among other things, that led to the Renaissance in Europe.

The invention of printing press, which was an aspect of the Renaissance in the fifteenth century, also helped to spread the numbers in Europe. As long ago as in 1478, a book printed in Venice, Italy, made the following remark about zero: "... 0 is called cipher or 'nulla', i.e., the figure of nothing... by itself it has no value, although when joined with others it increases their value."

In short, thanks to the Crusades and the printing press, Indian numbers, including zero, began to spread fast in Europe.

The Indian numbers first entered Spain, then Italy, France, England, and Germany. By the end of the sixteenth century, the abacus and other mechanical devices were given up and the Indian numbers were adopted completely. The entire Europe was swept off its feet by the numbers. In fact, their

**Nicolaus Copernicus**
**(1473-1543)**

A Polish astronomer. He discovered that Ptolemy's conclusions about the sun going round the earth were wrong as was the Church's belief that earth was the centre of the universe. He observed that the earth and the other planets go round the sun.

**Galileo Galilei**
**(1564-1642)**

An Italian mathematician, astronomer and physicist. Galileo was the first to use a telescope to study the skies. He declared that the earth revolved round the sun, in support of the heliocentric theory.

adoption turned out to be the turning point in the history of mathematics and science. Even the great French mathematician Pierre Laplace (1749-1827) wondered how the invention of these numbers escaped the genius of Archimedes and Apollonius, the two greatest Greeks of ancient times! Had these Greek mathematicians invented the numbers, he lamented, science would have advanced far more than what it had in his days. In any case, Indian numbers, including zero, showed their potential as soon as they entered Europe.

In 1543, the Polish monk and astronomer Nicolaus Copernicus (1473-1543) came forward with the theory that

earth and other planets move around the sun in elliptical paths. This theory opposed the then popular theory which claimed that the sun and planets moved around the earth. Copernicus had first observed the movements of planets and on the basis of mathematics predicted their future course according to his theory. His theory triumphed when his predictions came true. The theory created a revolution in science because for the first time some basic truths about the skies had been discovered using mathematics. (In the fifth century Aryabhata had propounded that the earth is round and that it rotates on its own axis.)

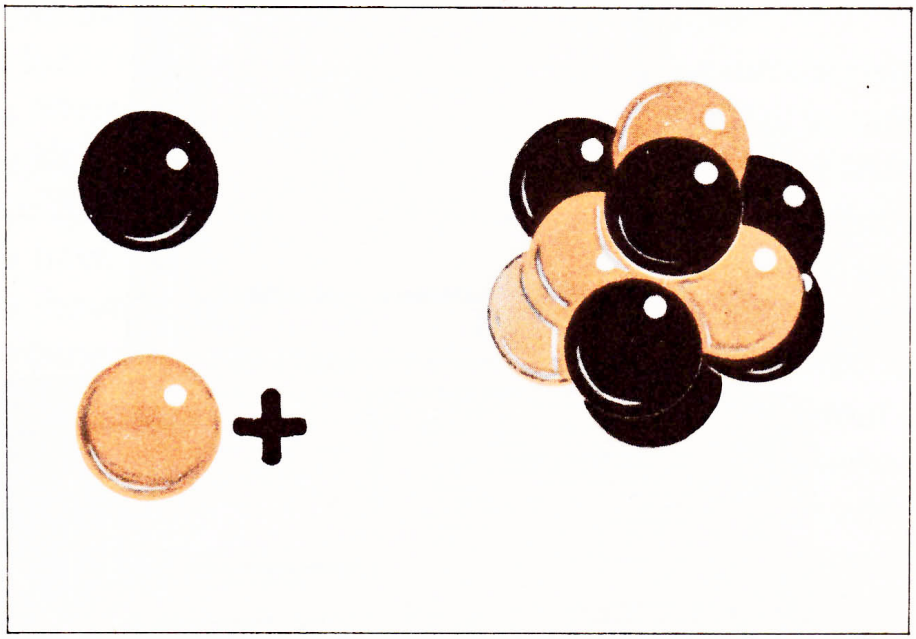
Subsequently, the Dutch astronomer Johannes Kepler (1571-1630) also forwarded the laws that govern the motion of planets using mathematics. It was however not until Galileo Galilei (1564-1642) conducted his famous experiments on falling bodies from the Leaning Tower of Pisa that mathematics was accepted as a tool to understand nature in Europe.

With the development of algebra, Indian numbers, including zero, enabled these men of science to conduct quantitative measurements for the study of nature. By inventing calculus to conduct his studies on gravitation and laws of motion, Isaac Newton (1642-1727) further expanded the scope of mathematics in scientific experiments. In fact, mathematics became the touchstone of science and continues to be so.

In due course, zero began to acquire the status of a reference point in all scientific measurements. No instrument or measuring device, whether a voltmeter or a microscope, could measure without it. In the early nineteenth century, when the Electrical Age was ushered in, zero and its bye-products—negative and positive values—acquired a new

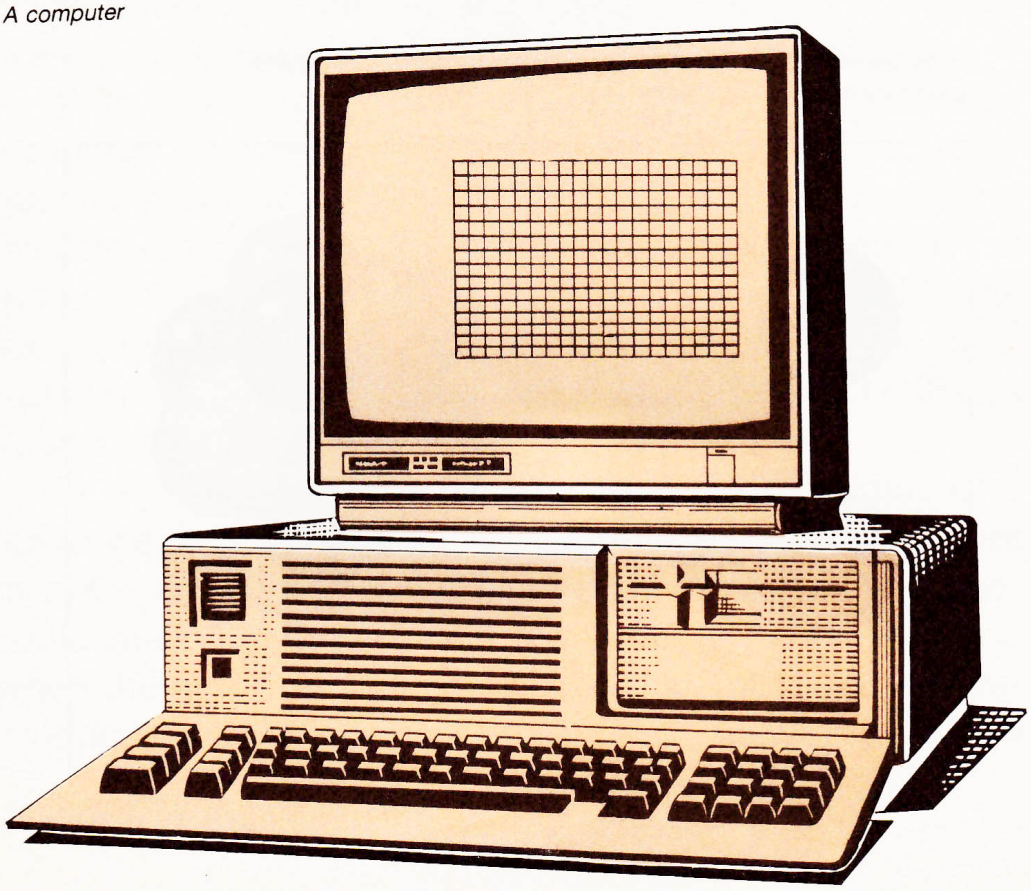
meaning and status. Negative and positive electric charges and currents became the byword and led to advances in electricity and then electronics. In the early part of the present century, electrically charged negative and positive particles, such as electrons and protons respectively, became the foundation of nuclear physics and then particle physics. Even modern physics put forward the fascinating concept of matter and anti-matter, whose basis is zero. Matter and anti-matter are almost like positive and negative numbers. If matter and anti-matter were to meet, they would explode in a puff of radiation – everything coming to a naught! In fact, one could speculate on how our universe came into being with an explosive bang – the Big Bang theory – only when time and space are believed to have become zero!

*The atomic nucleus consists of the positively-charged protons and neutrons which have no charge.*



Meanwhile, Indian numbers, including zero, also inspired European scientists like Blaise Pascal, Charles Babbage, and others to build calculating machines. It is the ease with which they could be counted and tabulated through mechanical means, that such machines were built. Even today's computers—the electronic progeny of these machines— function on the basis of binary mathematics instead of decimal mathematics. Just as in decimal mathematics ten numbers are employed, in binary mathematics, only two numbers—0 and 1—are used. For example, in binary mathematics, 2 is represented by 10, 3 by 11, 16 by 10000, 29 by 11101, and so on.

*A computer*

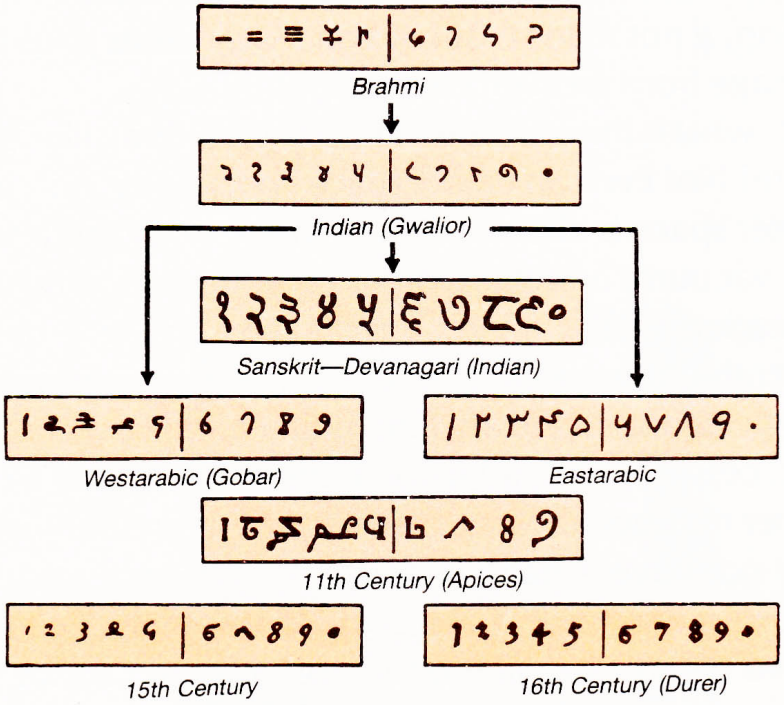


Apart from being actually involved, zero as a concept has also entered social sciences and engineering. Zero-growth population is a stable population when births equal deaths; a zero-defect gadget is a trouble-free gadget, and so on. Indeed, it is only on examining a thing or subject in detail that one sees the presence of zero and its importance therein. It has woven a net around the earth as it were. It is also serving its purpose dutifully in the spacecraft heading towards distant planets and stars, announcing our presence to alien civilizations, if there are any. It would not be surprising if this Indian invention, if not in form but in concept, comes to us as a part of message from an alien civilization!

But, what is this zero after all? Does anything like zero exist in nature? No! Even an empty space contains air, not 'nothing'. The outer space is also not all nothingness or vacuum. Nature abhors vacuum, and therefore a zero. It exists in the mind. It is a creation of the mind. But as seen above,it has led to considerable advances in science and engineering. That is where the genius of the ancient Indian mind lies.

But, certainly, it is not mere nothing. It is a number too like any other number and can be operated upon. For instance, if you do not have a bank account, you cannot say that you have zero money in it. Unless you have a bank account and you have withdrawn all money from it, you cannot say that you have zero in your bank. That is why sometimes, computerised departments send 'zero electricity bills' to the users because it is only after some transactions that zero comes into the picture. Also, it does not simply remain a zero if it is added to a number. For instance, if one zero is added to a hundred it becomes a thousand, or 128 can become 1028 or 1208 or 1280 depending upon where you place the zero.

In short, it is a number with a potential to work wonders, as it has already done and will continue to do. Is it possible that when ancient Indian mathematicians gave it the symbol of a circle with a dot inside – something immense being encircled or held captive – they knew about its tremendous potentialities?

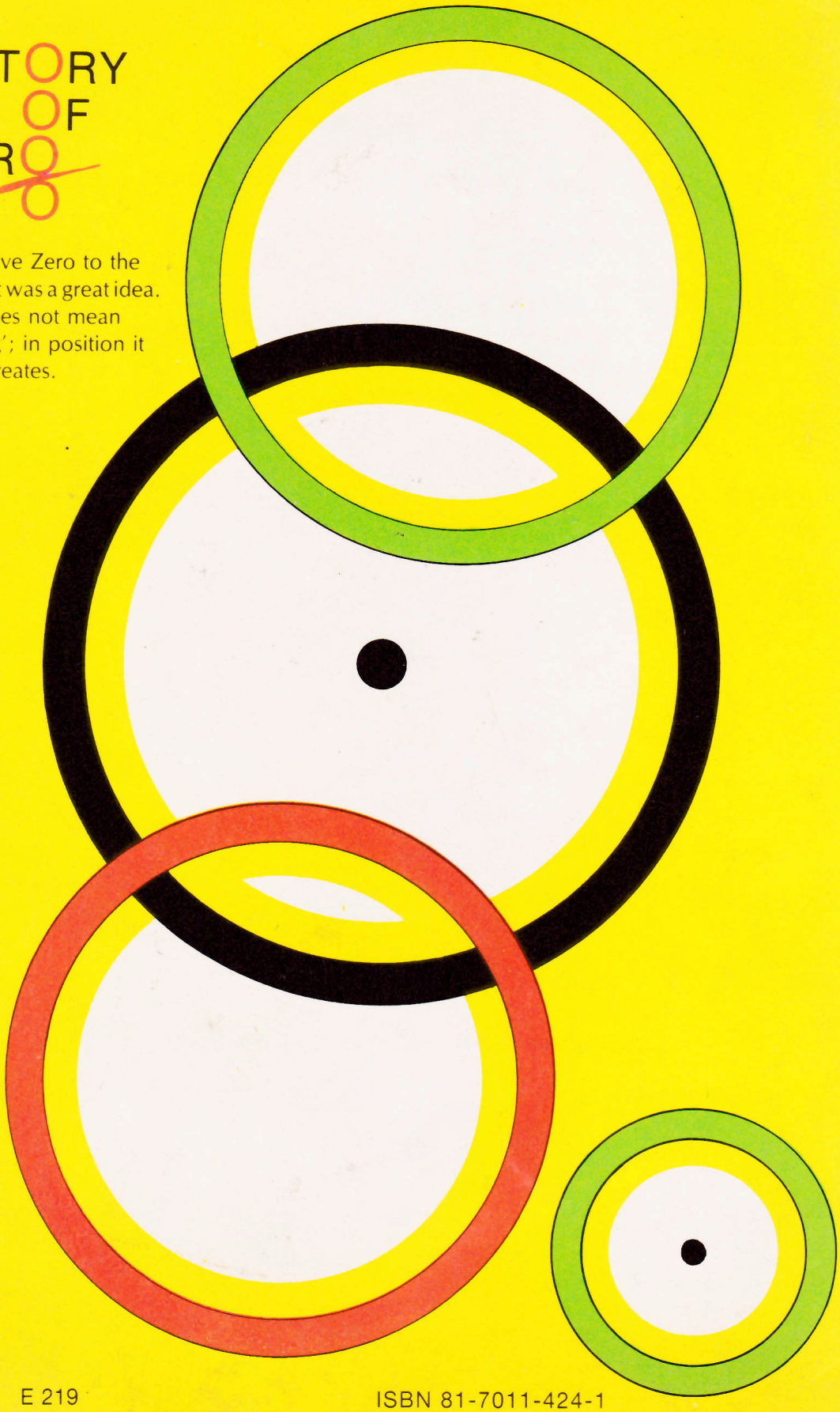



*Genealogy of digits*

*The algorist and the abacist*

# STORY OF ZERO

India gave Zero to the world. It was a great idea. Zero does not mean 'nothing'; in position it adds, creates.



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